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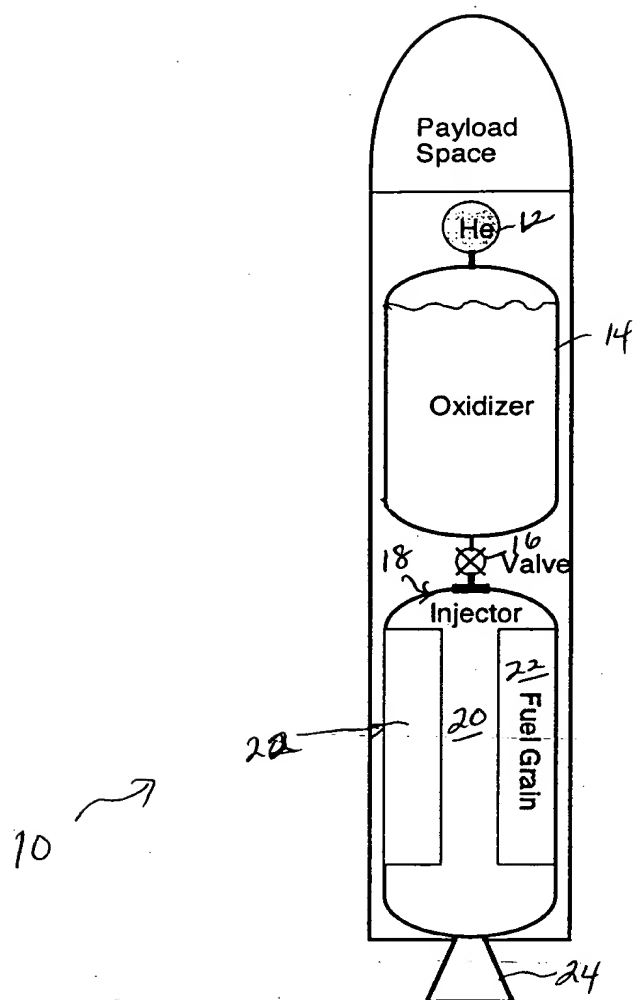


Figure 1: Schematic of a hybrid rocket utilizing a blow-down oxidizer feed system.

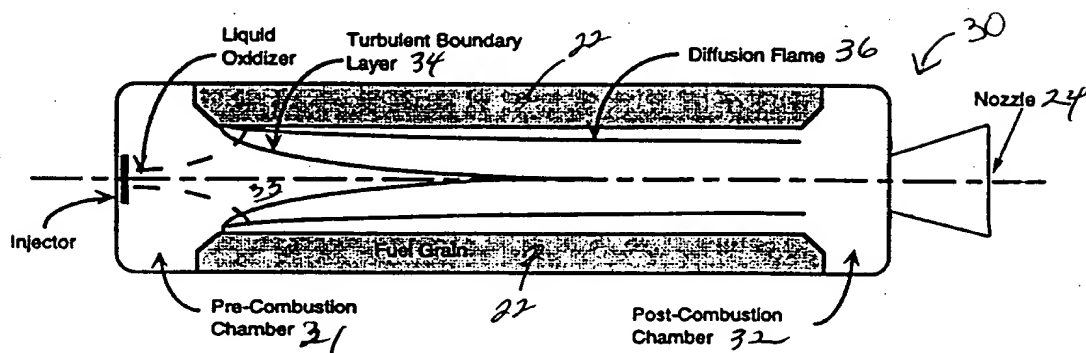


Figure 2. Schematic of a single port hybrid rocket motor.

The diagram illustrates a burning coal particle with three distinct regions: a gas phase above, a liquid layer in the middle, and a solid fuel grain at the bottom. The gas phase is characterized by density  $\rho_g$ , velocity  $u_g$ , temperature  $T_g$ , and pressure  $P_g$ . A horizontal arrow indicates the gas flow direction. The liquid layer is shown as a hatched region. The solid fuel grain is depicted with a stippled texture. Key temperatures are marked:  $T_{flame}$  at the gas-liquid interface,  $T_{interface}$  at the liquid-solid interface,  $T_m$  (melting point) at the solid surface, and  $T_a$  (ambient temperature) at the bottom. A velocity profile  $U_{interface}$  is shown as a curve within the gas phase. A radial coordinate  $r$  is indicated by a downward arrow on the left. A dashed line represents the initial particle surface, and a solid line shows the current, eroded surface.

**Figure 4: Schematic of velocity and temperature profiles in a liquefying hybrid rocket.**

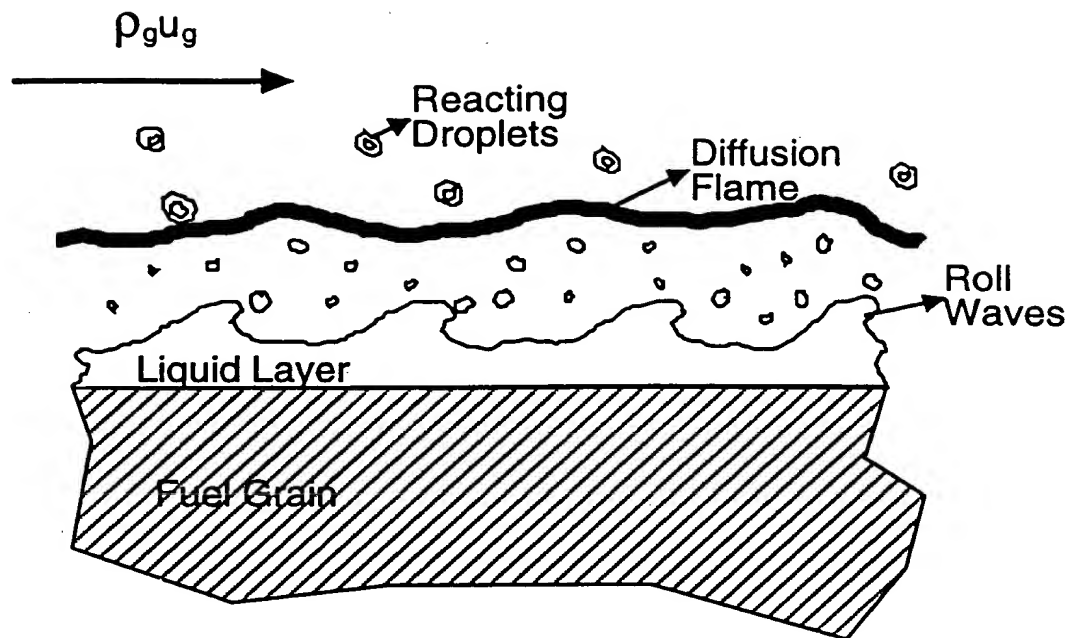


Figure 5: Schematic of the entraining hybrid combustion configuration.

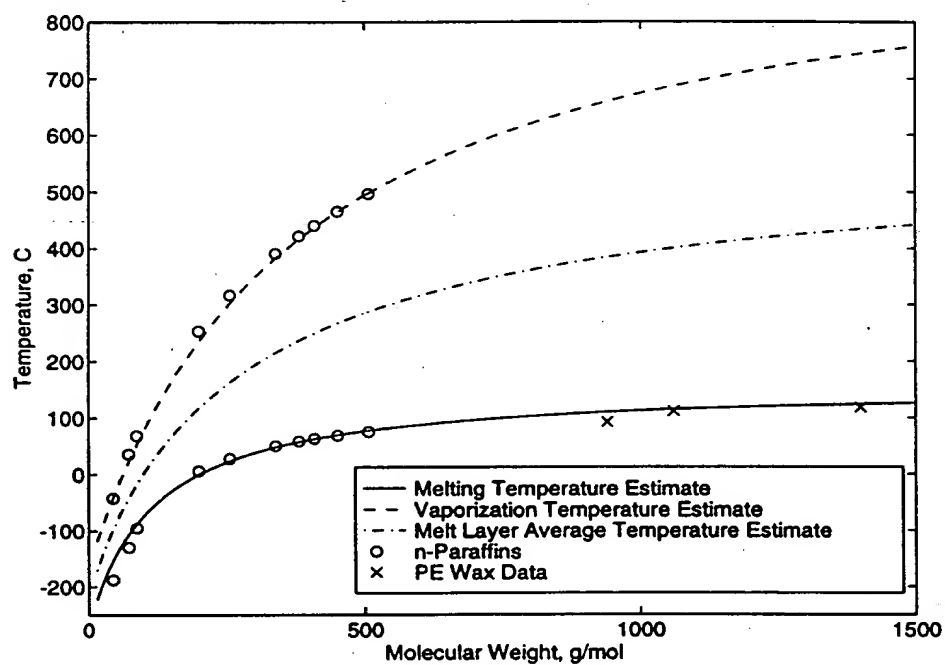


Figure 6. Melting, vaporization and average melt layer temperatures of n-paraffins as a function of molecular weight.

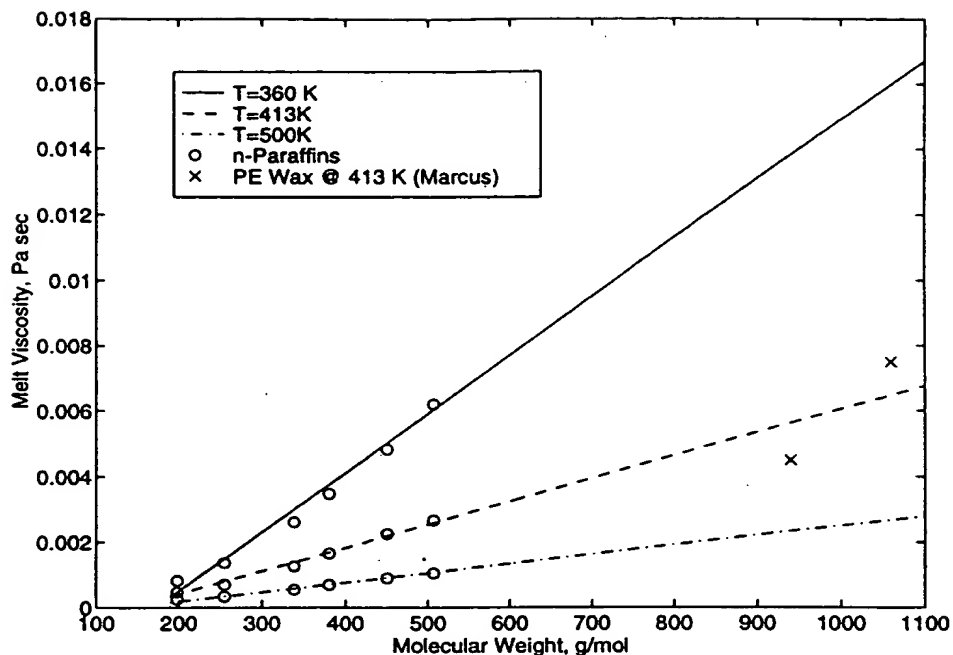


Figure 7. Viscosity as a function of the molecular weight for various n-paraffins and two highly crystalline polyethylene waxes.

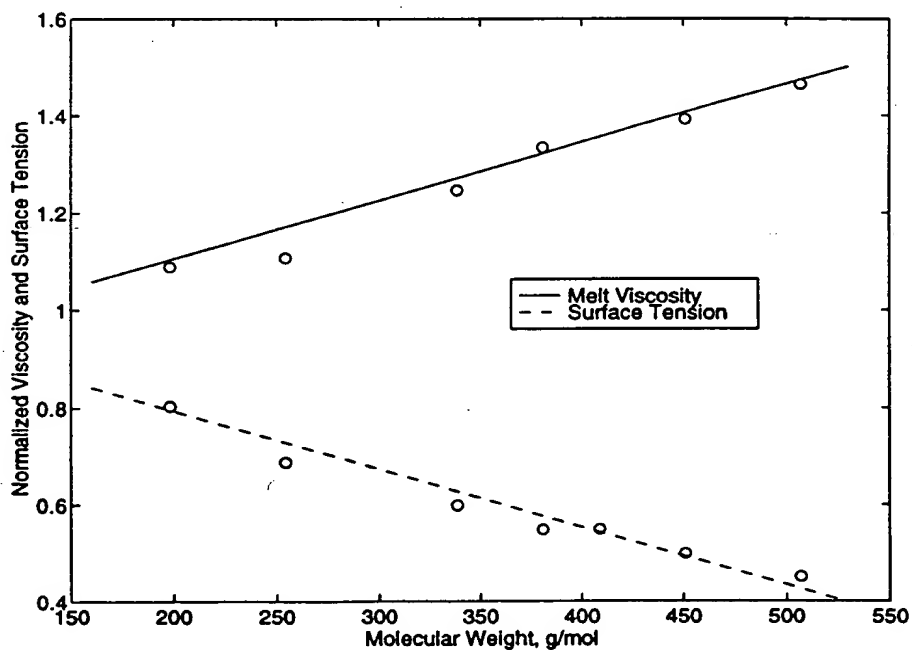


Figure 8. Viscosity and surface tension of the melt layer as a function of the molecular weight for various n-paraffins. The values of viscosity and surface tension are normalized with respect to the reference values (n-pentane).

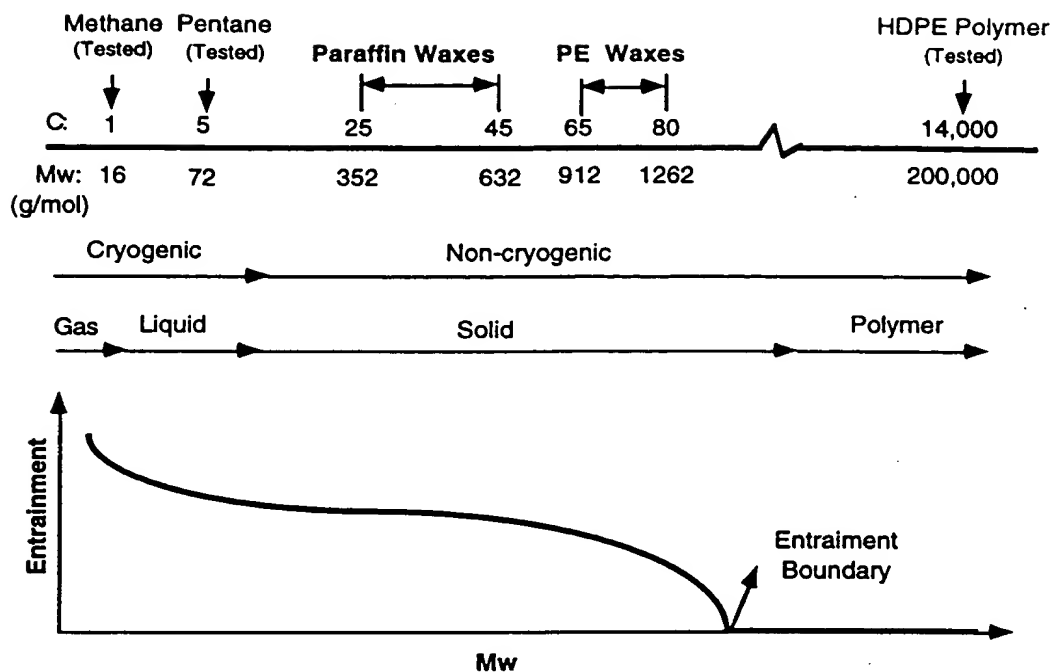


Figure 9. Overall picture for  $C_nH_{2n+2}$  series.

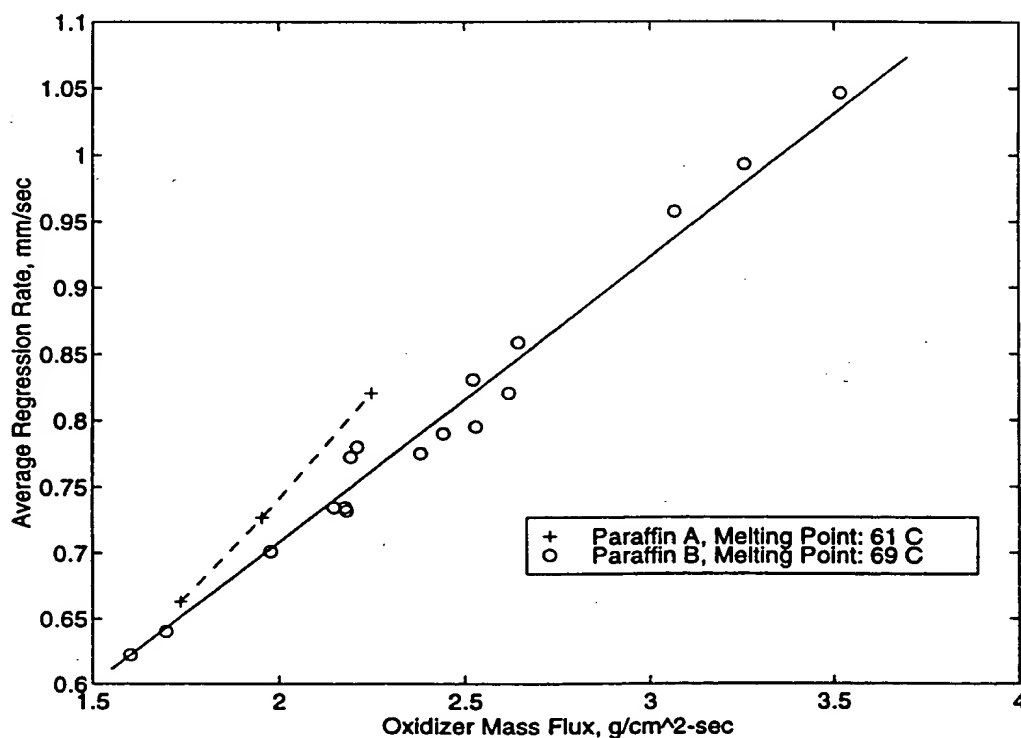


Figure 10: Measured regression rates as a function of oxidizer mass flux for paraffins A and B.

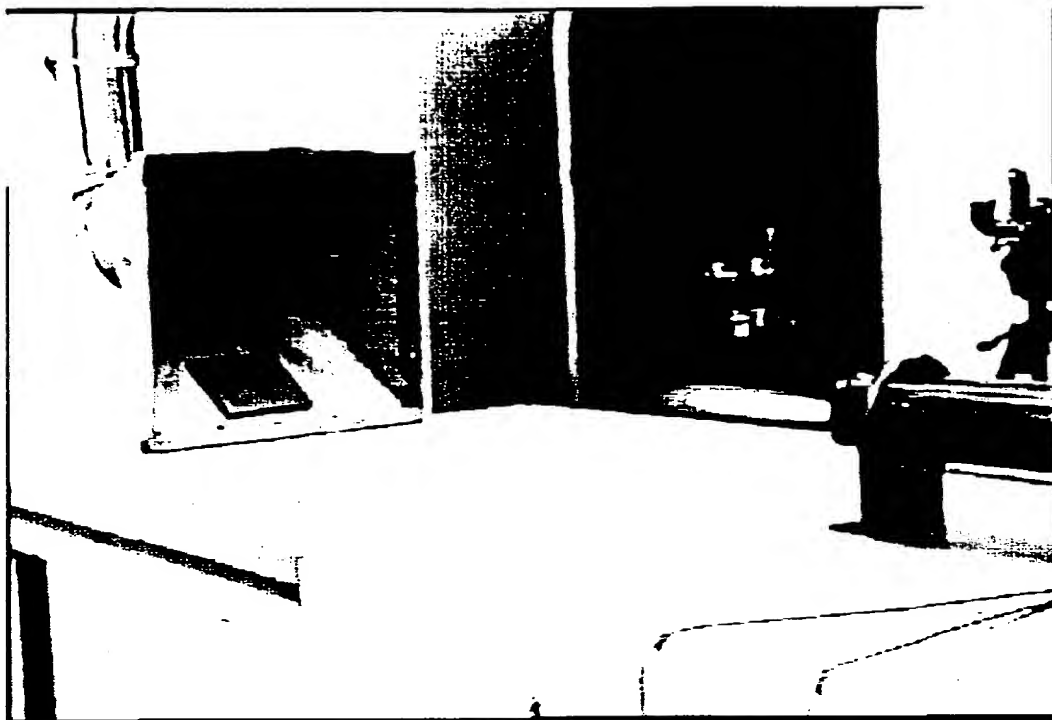


Figure 11a: Picture of the plume for the PMMA/GOX system.

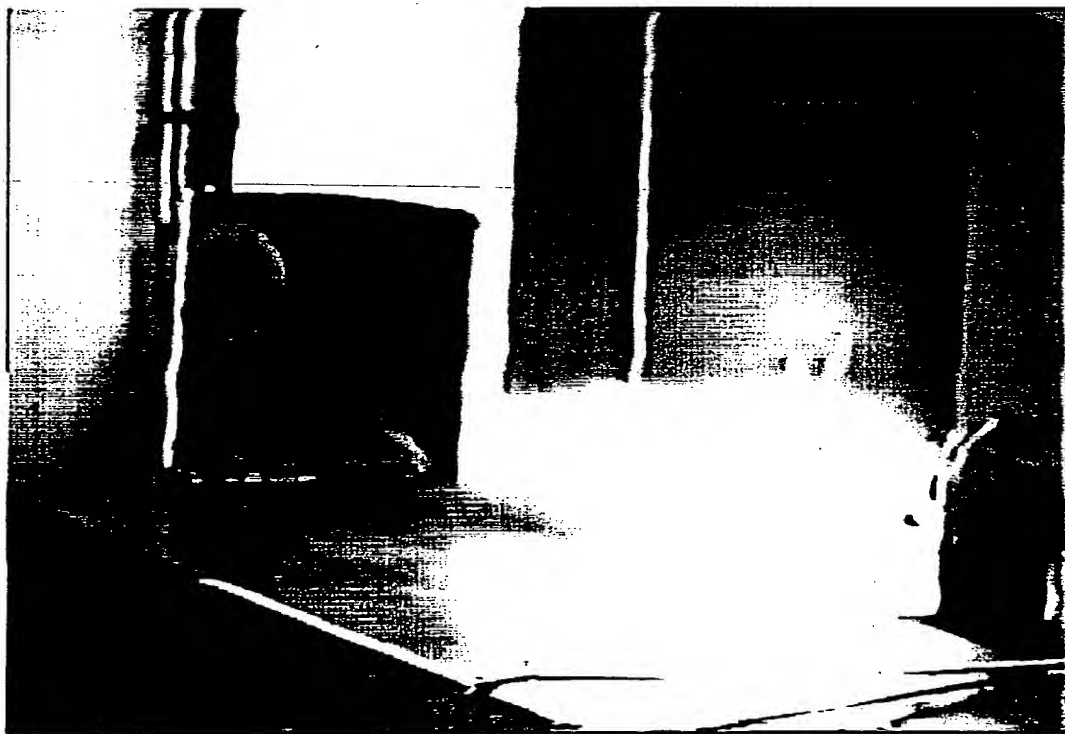


Figure 11b: Picture of the plume for the paraffin wax (grade B)/GOX system.

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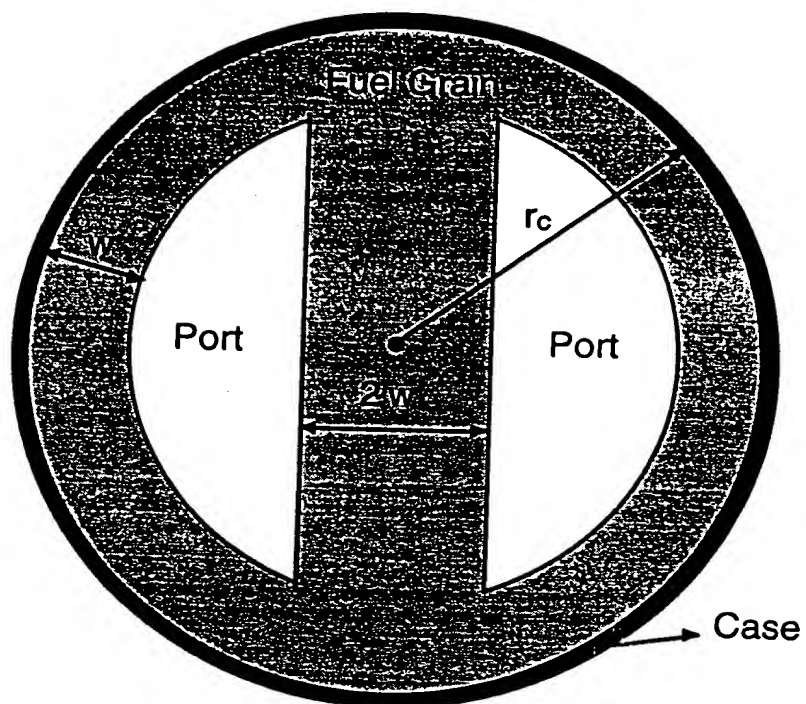


Figure 12a: Schematic of a Double-D hybrid port configuration

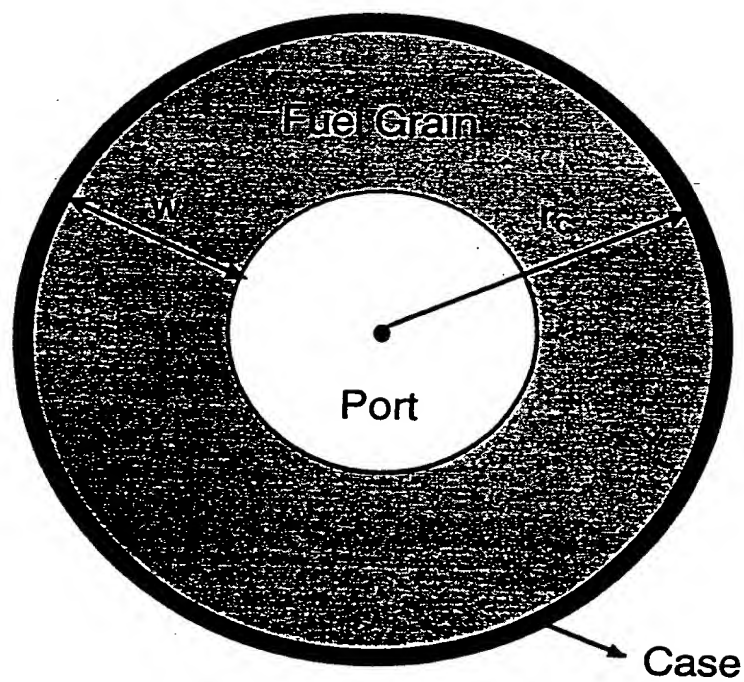


Figure 12b: Schematic of a circular (single port) hybrid port configuration

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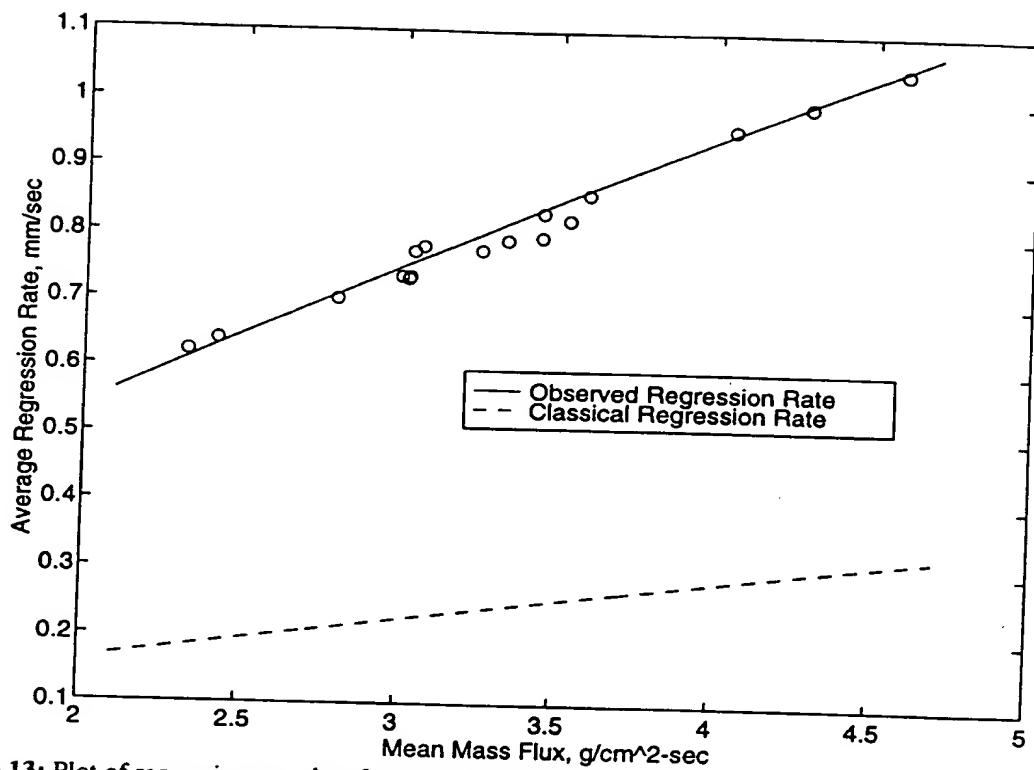


Figure 13: Plot of regression rate data for paraffin wax B and the estimated classical regression rate.

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